



2018

Bloom surveillance from Space, an update on CyAN and other bloom monitoring activities at NOAA

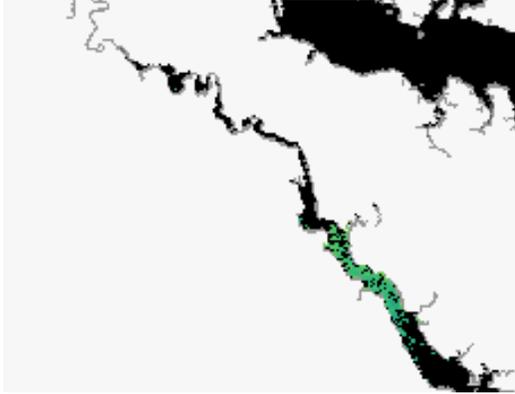
Shelly Tomlinson

National Oceanic and Atmospheric Administration, NCCOS

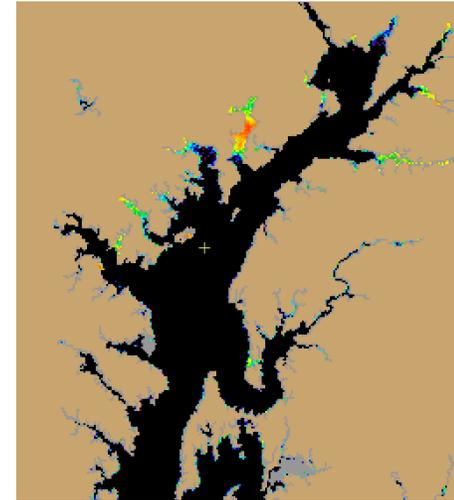


Custom Satellite-derived products for algal bloom monitoring

OLCI Cyanobacteria (Clcyano)



Relative Chlorophyll (Gilerson)

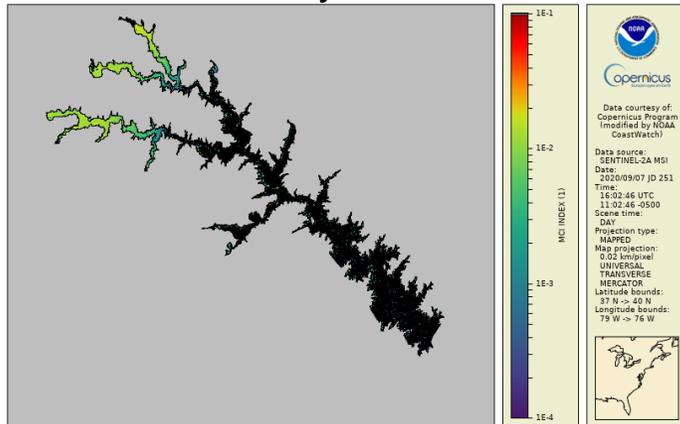


Non-Cyano Index (chl-a with negligible fluorescence)

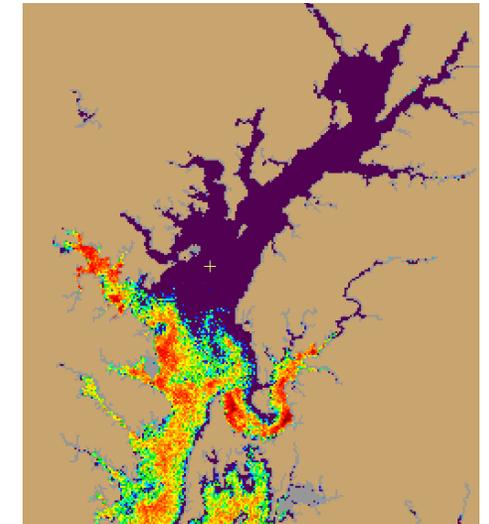
True Color



Hi-res MCI for cyanobacteria



RBD Fluorescence

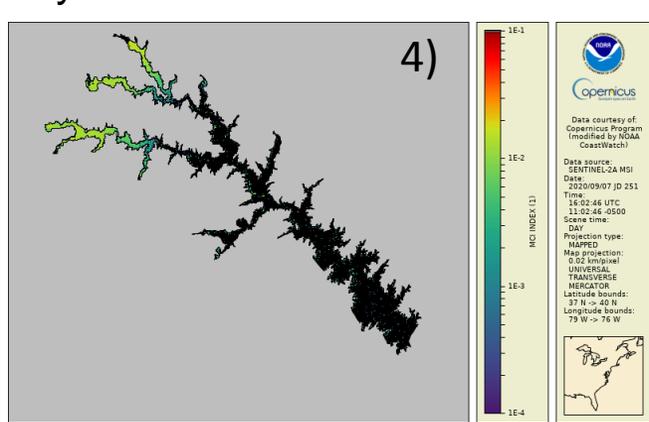


Note: Imagery derived from Copernicus Sentinel data from EUMETSAT
Available from Chesapeake Bay at https://coastwatch.noaa.gov/cw_html/NCCOS.html



Algal Bloom Monitoring

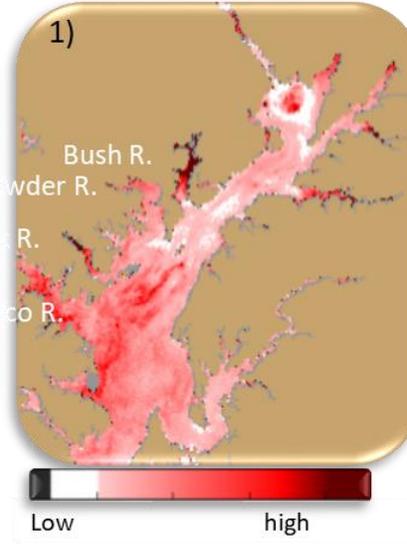
MCI and Cyano Index for cyanobacteria



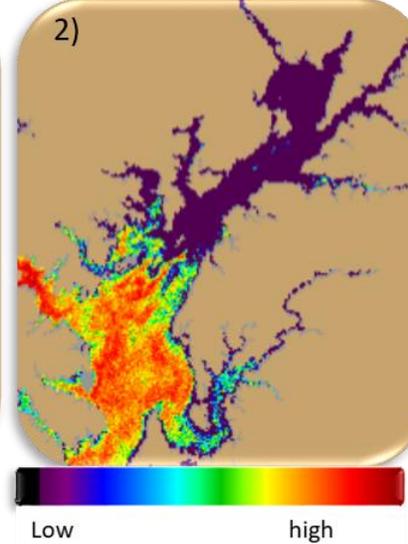
True color



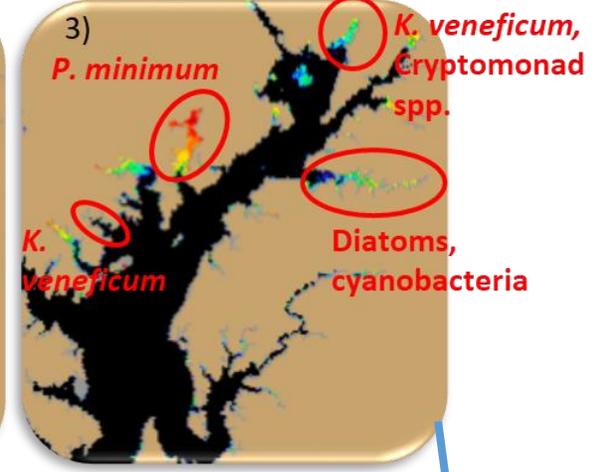
Relative Chl *a*



Chl fluorescence

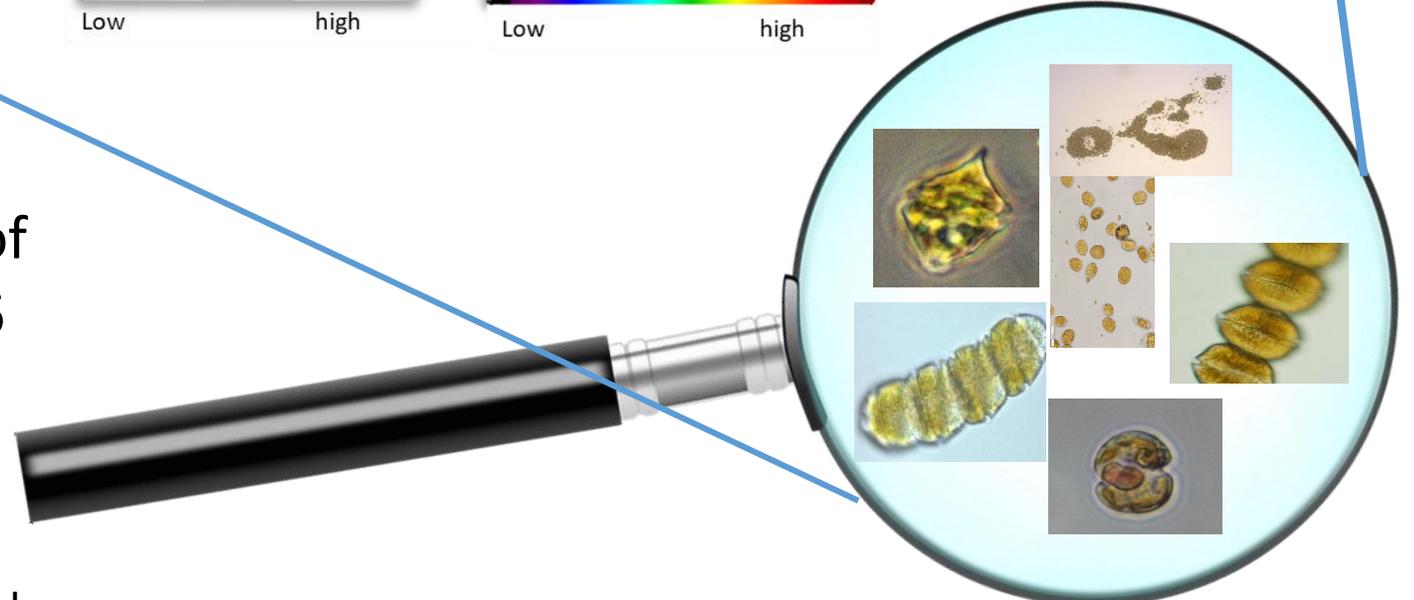


Non-fluorescing



Developing and providing algorithms for bloom monitoring routinely to MD DNR, MDE, VA Dept. of Health and VIMS from OLCI since 2016

- (1) Red Band Difference (RBD) (Amin et al., 2009)
- (2) Red-Edge (Gilerson, 2010)
- (3) Cyanobacteria Index (Wynne et al., 2008) modified by a negative shape at 620 nm
- (4) Maximum Chlorophyll Index (MCI) (Gower et al., 2008)



https://coastwatch.noaa.gov/cw_html/NCCOS.html

NCCOS Algal Bloom Beta/Experimental Products

Search Criteria

Region:

Chesapeake Bay

Product:(CTRL-click multiple)

True Color
Chlorophyll-a (Gilerson)
Relative Fluorescence
Cyanobacteria Index

Sensor: OLCI MSI

From: (MM/DD/YYYY)

08/22/2020

To: (MM/DD/YYYY)

08/27/2020

Search

The Harmful Algal Bloom - Forecasting Branch (HAB-FB) is a research group within the National Oceanic and Atmospheric Administration (NOAA), National Centers for Coastal Ocean Science (NCCOS) tasked with forecasting and monitoring HABs. One of the more effective ways to do so is through satellite based monitoring, which provides a synoptic view at high temporal resolution. The HAB-FB has established a routine and automated processing capability for satellite-derived products pertaining to the color of water. Water color can be used as proxy for various geophysical parameters, such as chlorophyll-a, turbidity, and water depth. All of our products are generated from mapped reflectance products, which we refer to as "level 3" products:

- **True Color** : a Red, Green, Blue (RGB) composite image
- **Chlorophyll-a (Gilerson)** : chlorophyll a concentration determined by a near-Infrared to red ratio as described by Gilerson et al. (2010).
- **Cyanobacteria Index** : the relative abundance of cyanobacteria biomass as determined by the cyanobacteria index algorithm developed by Wynne et al. (2008).
- **Low fluorescing Algae** : the relative abundance of phytoplankton which are low or non-fluorescing and do not contain phycocyanin (non-cyanobacteria).
- **Relative Fluorescence** : the relative chlorophyll fluorescence representative of chlorophyll concentration for high biomass blooms, determined by the Red-Band Difference developed by Amin et al. (2009).
- **Maximum Chlorophyll Index (MCI)**: The Maximum Chlorophyll Index (MCI) detects high biomass blooms and shows relative density patches of Chl-a, as developed by Gower et al. (1999).

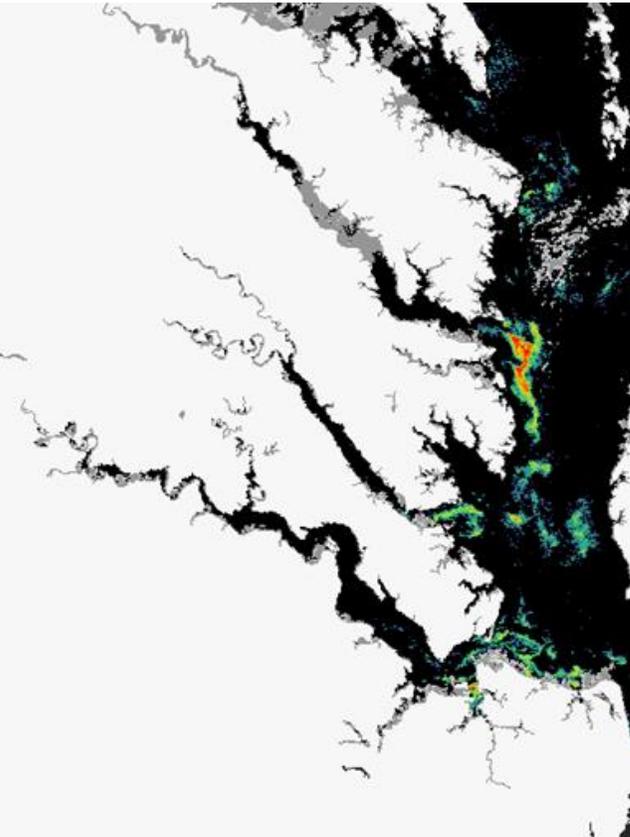
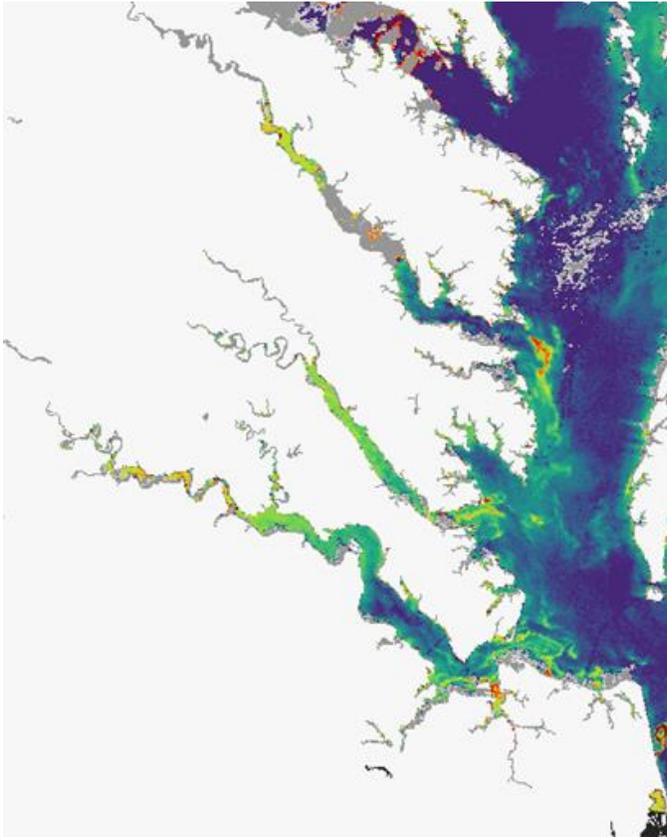
Sentinel-2 MSI imagery does not have a cloud mask applied at this time. Please consult the true color, as black pixels may indicate clouds or no bloom. For more information on these products, refer to the [NCCOS products website](#).

Bloom Case Scenarios

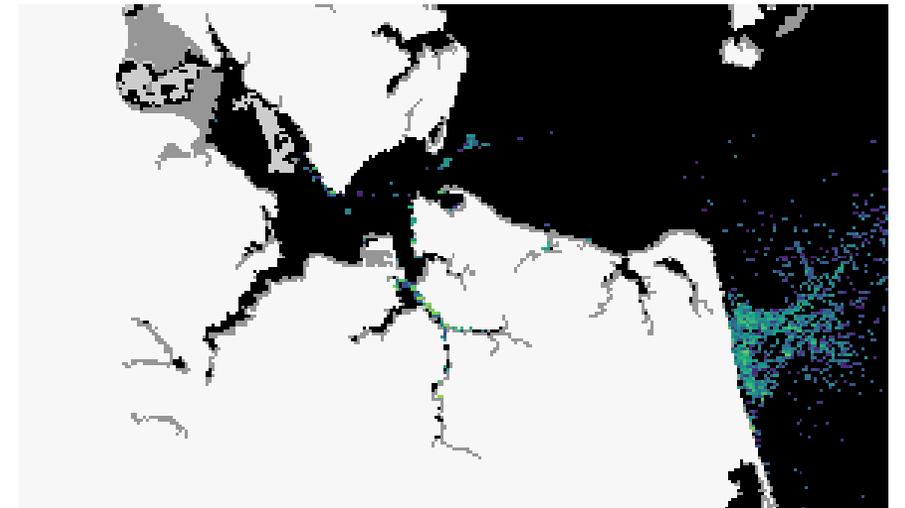
Margalefidinium polikrikoides

Gilerson Chl a: Aug 12, 2020

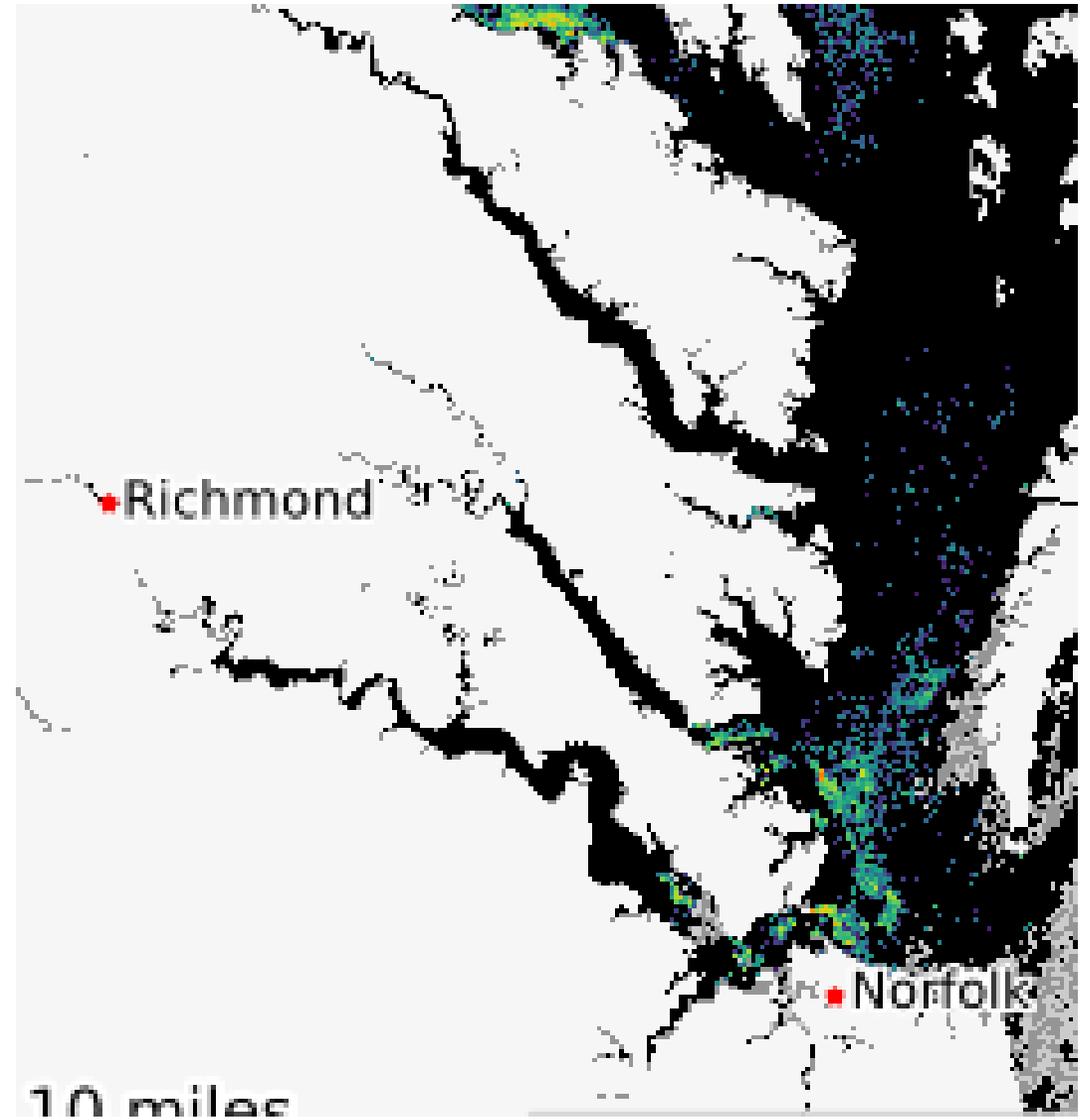
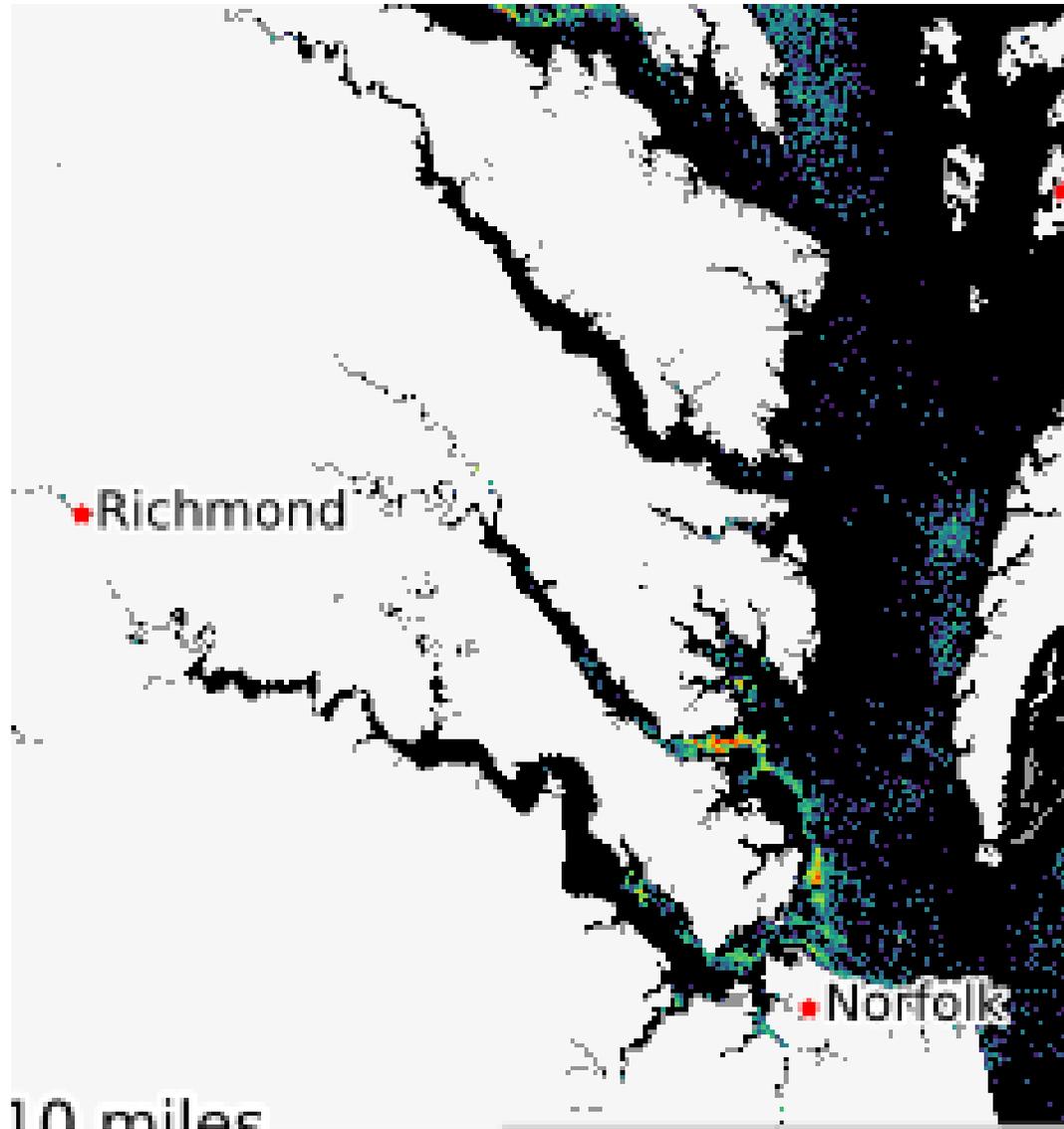
Chl Fluorescence (RBD): Aug 12, 2020



Lafayette River-Atlantic RBD
July 20-Aug 11, 2020



Alexandrium monilatum
OLCI RBD Sep 4, 2020

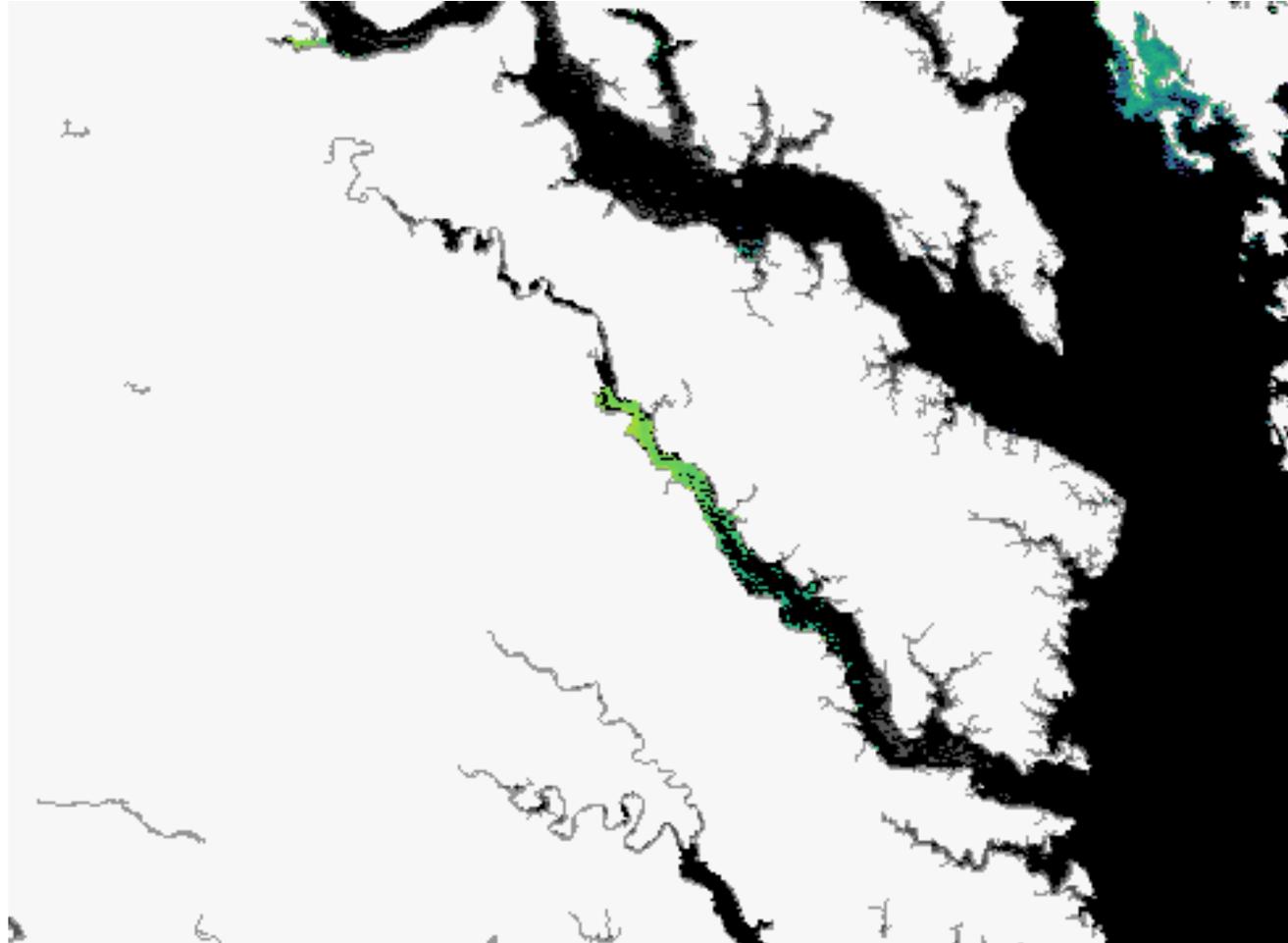


Rappahannock River

August 26, 2020

Event date: August 28 had 150,000cells/ml

Sentinel 3, OLCI Clcyano



Rappahannock River

October 7, 2020

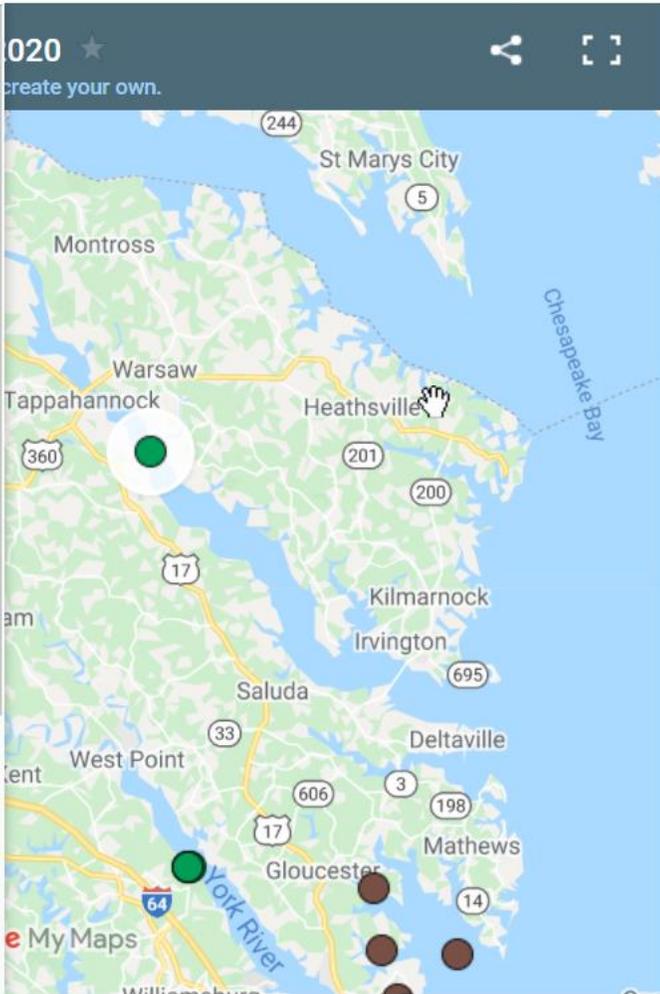
Event date: ~11,000 cells/mL on October 8, 2020

← Rappahannock River

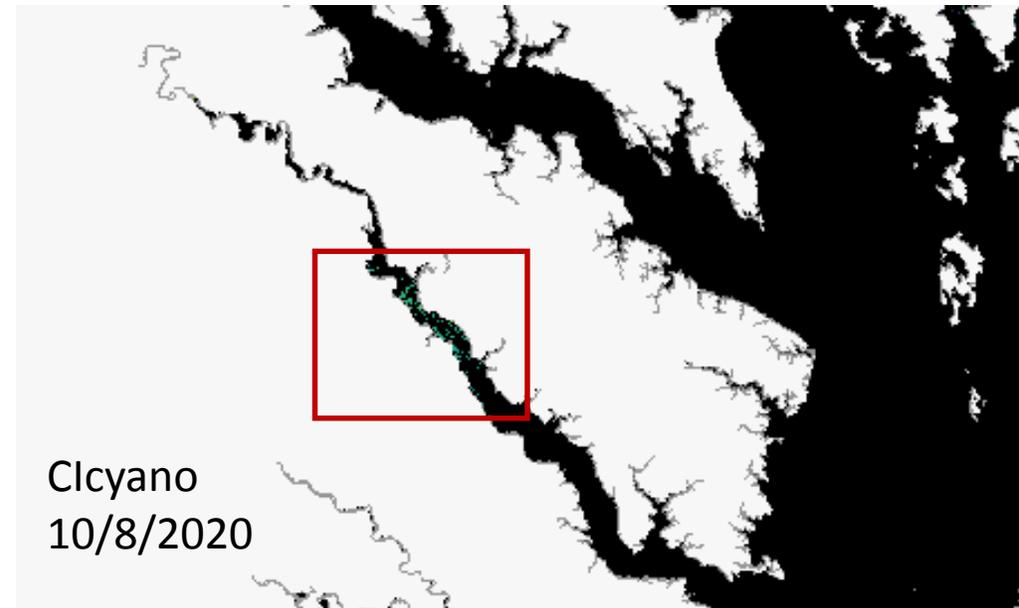
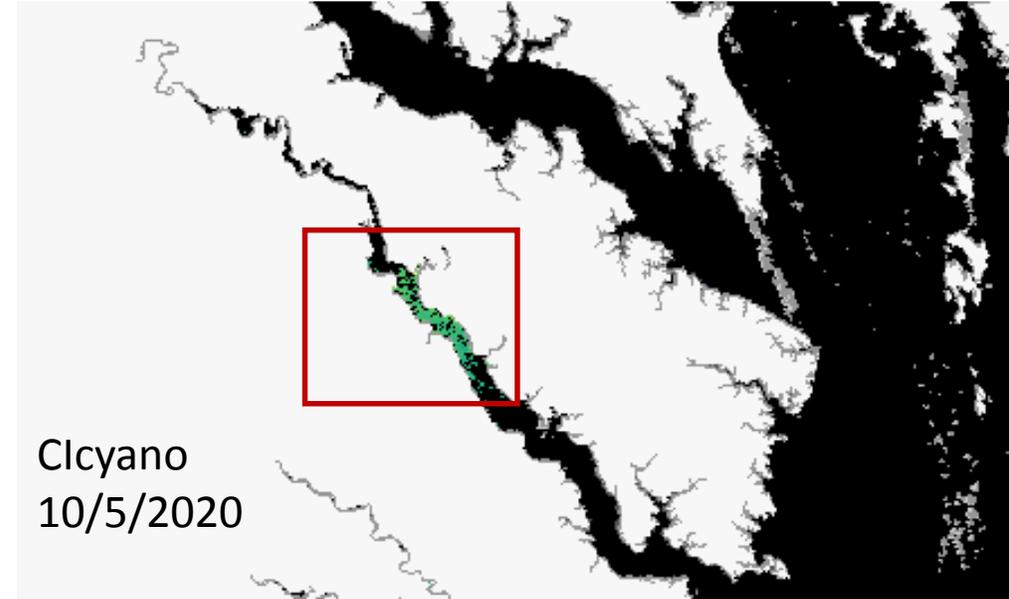
name
Rappahannock River

Sample Date
8/28/20

description
Results of samples collected on 8/28/20 indicated cyanobacteria (primarily Planktolyngbya) at densities which would typically trigger the issuance of a swimming advisory in recreational waters. However, due to the multiple rain events which subsequently occurred prior to the receipt of results from the laboratory, continued surveillance using satellite imagery was opted over the issuance of an advisory. Satellite imagery indicated the dissipation of the bloom as results were received. Toxin analyses were all near or below detection limits and far below advisory levels. The rain



Sentinel 3, OLCI



Smith Mountain Lake
August 26, 2020
Event date: 8/24/2020



Data courtesy of:
Copernicus Program
(modified by NOAA
CoastWatch)

Data source:
SENTINEL-2B MSI
Date:
2020/08/26 JD 239
Time:
16:13:00 UTC
11:13:00 -0500
Scene time:
DAY
Projection type:
MAPPED
Map projection:
0.02 km/pixel
UNIVERSAL
TRANSVERSE
MERCATOR
Latitude bounds:
36 N -> 39 N
Longitude bounds:
81 W -> 78 W



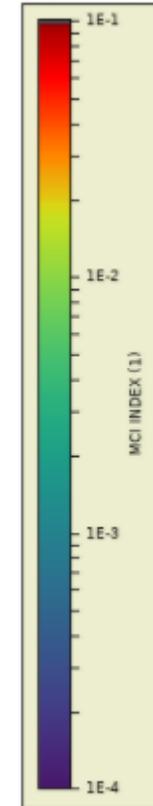
Data courtesy of
Copernicus Program
(modified by NOAA
CoastWatch)

Data source:
SENTINEL-2B MSI
Date:
2020/08/26 JD 239
Time:
16:13:00 UTC
11:13:00 -0500
Scene time:
DAY
Projection type:
MAPPED
Map projection:
0.02 km/pixel
UNIVERSAL
TRANSVERSE
MERCATOR
Latitude bounds:
36 N -> 39 N
Longitude bounds:
81 W -> 78 W



Imagery thanks to Michael Sorocco, NOAA CoastWatch

Smith Mountain Lake
August 26, 2020
Event date: 8/24/2020





Data courtesy of:
Copernicus Program
(modified by NOAA
CoastWatch)

Data source:
SENTINEL-2B MSI
Date:
2020/08/26 JD 239
Time:
16:13:00 UTC
11:13:00 -0500
Scene time:
DAY
Projection type:
MAPPED
Map projection:
0.02 km/pixel
UNIVERSAL
TRANSVERSE
MERCATOR
Latitude bounds:
36 N -> 39 N
Longitude bounds:
81 W -> 78 W

Smith Mountain Lake
August 26, 2020
Event date: 8/24/2020



← Smith Mountain Lake - Upper Bl... 

name
Smith Mountain Lake - Upper Blackwater Arm

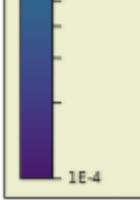
Sample Date
8/24/20

description
Results of samples did not indicate cyanobacteria were present, however, cyanobacteria toxin was detected at levels which are well below levels which could pose a health risk. Be aware of algae blooms and avoid water that smells, is discolored, or where there are dead fish present. Report blooms and fish kills using the online HAB report form at www.SwimHealthyVa.com.

020   
create your own.



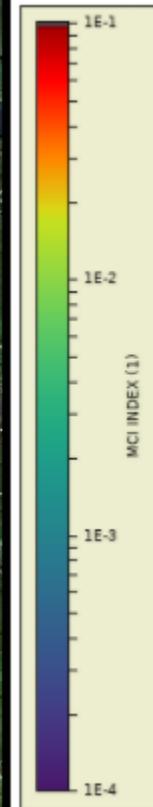
Map showing Smith Mountain Lake and surrounding areas (Moneta, Westlake Corner, North Shore, Union Hall, Glade Hill, Penhook, Ajax). A green dot indicates the sample location near North Shore. Road numbers (676, 678, 677, 636, 634, 122, 655, 654, 608, 670, 668, 711, 834, 655, 674, 40) are visible.



1E-4

Projection type:
MAPPED
Map projection:
0.02 km/pixel
UNIVERSAL
TRANSVERSE
MERCATOR
Latitude bounds:
36 N -> 39 N
Longitude bounds:
81 W -> 78 W

Smith Mountain Lake
August 26, 2020



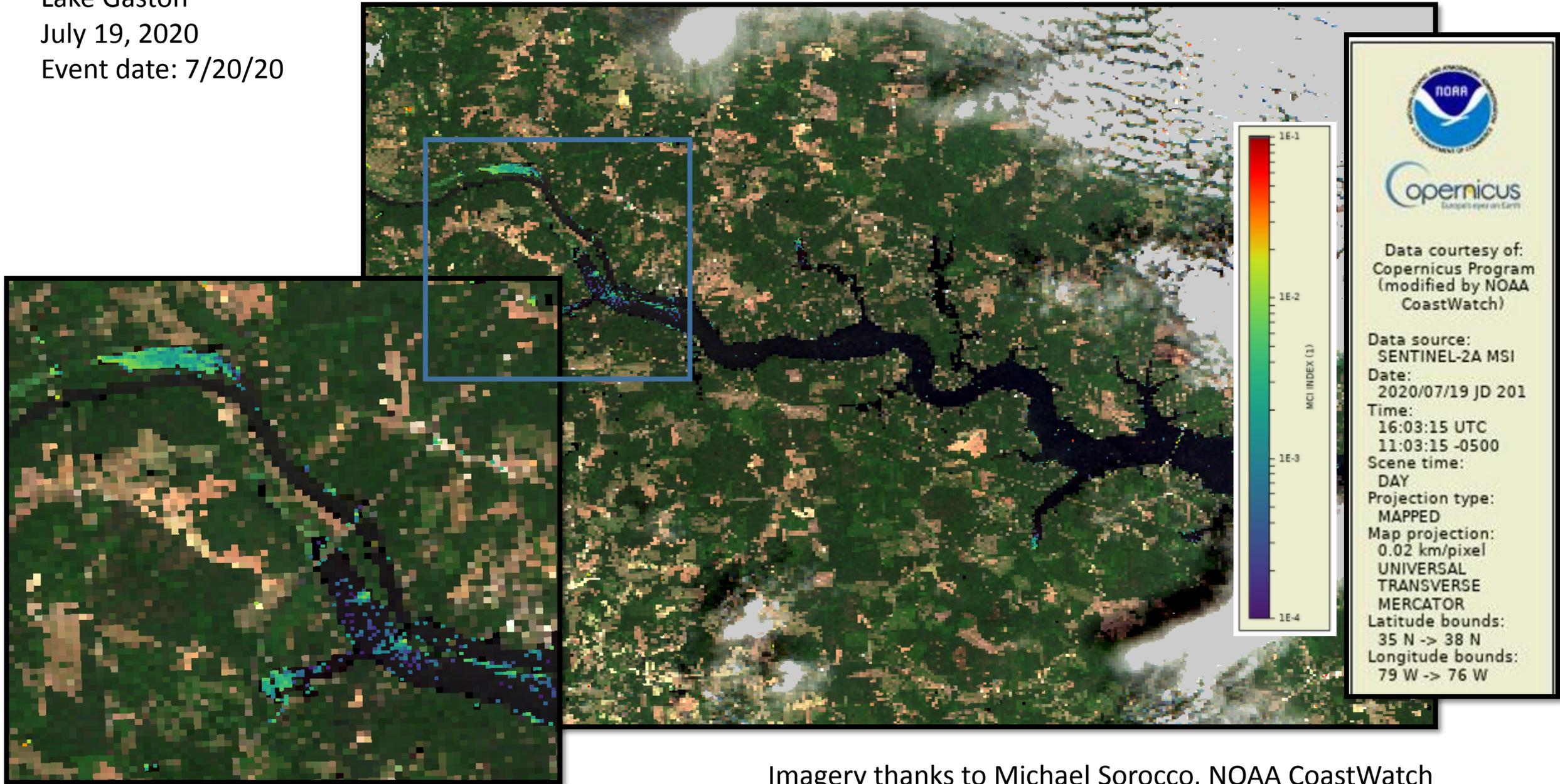



Data courtesy of:
Copernicus Program
(modified by NOAA
CoastWatch)

Data source:
SENTINEL-2B MSI
Date:
2020/08/26 JD 239
Time:
16:13:00 UTC
11:13:00 -0500
Scene time:
DAY
Projection type:
MAPPED
Map projection:
0.02 km/pixel
UNIVERSAL
TRANSVERSE
MERCATOR
Latitude bounds:
36 N -> 39 N
Longitude bounds:
81 W -> 78 W

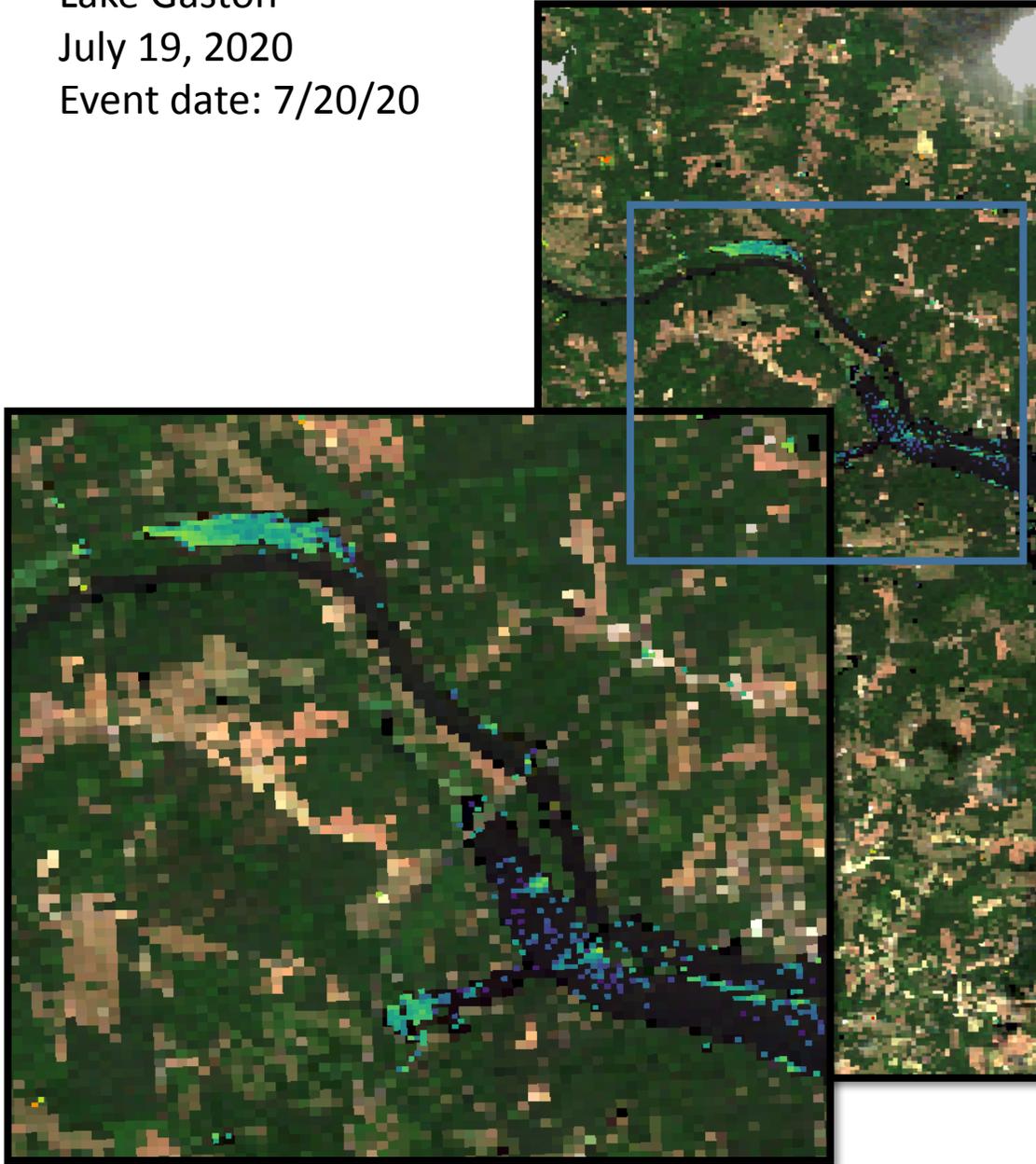
Imagery thanks to Michael Sorocco, NOAA CoastWatch

Lake Gaston
July 19, 2020
Event date: 7/20/20



Imagery thanks to Michael Sorocco, NOAA CoastWatch

Lake Gaston
July 19, 2020
Event date: 7/20/20



← Lake Gaston (site #2) 020 ★
create your own.

name
Lake Gaston (site #2)

Sample Date
7/20/20

description
Water samples collected indicate that no cyanobacteria cells were present, however cyanobacteria toxin was detected just above the lower limit of toxin tests, still well below levels which could pose a health risk. Be aware of algae blooms and avoid water that smells, is discolored, or where there are dead fish present. Report blooms and fish kills using the online HAB report form at www.SwimHealthyVa.com.

The map shows the Lake Gaston area in Virginia, North Carolina. It includes major roads like I-85, US-1, and US-615. Locations such as Bracey, Palmer Springs, and Wise are marked. Two green circular markers are placed on the eastern shore of the lake, indicating the sampling sites. A white circle highlights the southernmost marker.

TRANSVERSE
MERCATOR
Latitude bounds:
35 N -> 38 N
Longitude bounds:
79 W -> 76 W

1E-4

Imagery thanks to Michael Sorocco, NOAA CoastWatch



Cyanobacteria Assessment Network

epa.gov/cyanoproject



Slides courtesy of Blake Schaeffer, EPA and Bridget Seegers, NASA/USRA



Cyanobacteria Assessment Network (CyAN)

Multi-agency project EPA, NOAA, USGS, NASA

GOAL: Support the environmental management and public use of U.S. lakes by detecting and quantifying algal blooms and related water quality indicators using satellite data records.

Approach

Remote Sensing

Uniform and systematic approach for identifying cyanobacteria blooms.
Strategy for evaluation and refinement of algorithms across platforms.

Information Distribution

Bring the technology to EPA, states and tribal partners. Provide notifications and decision support

Economics

Behavioral responses and economic value of the early warning system.

Environment

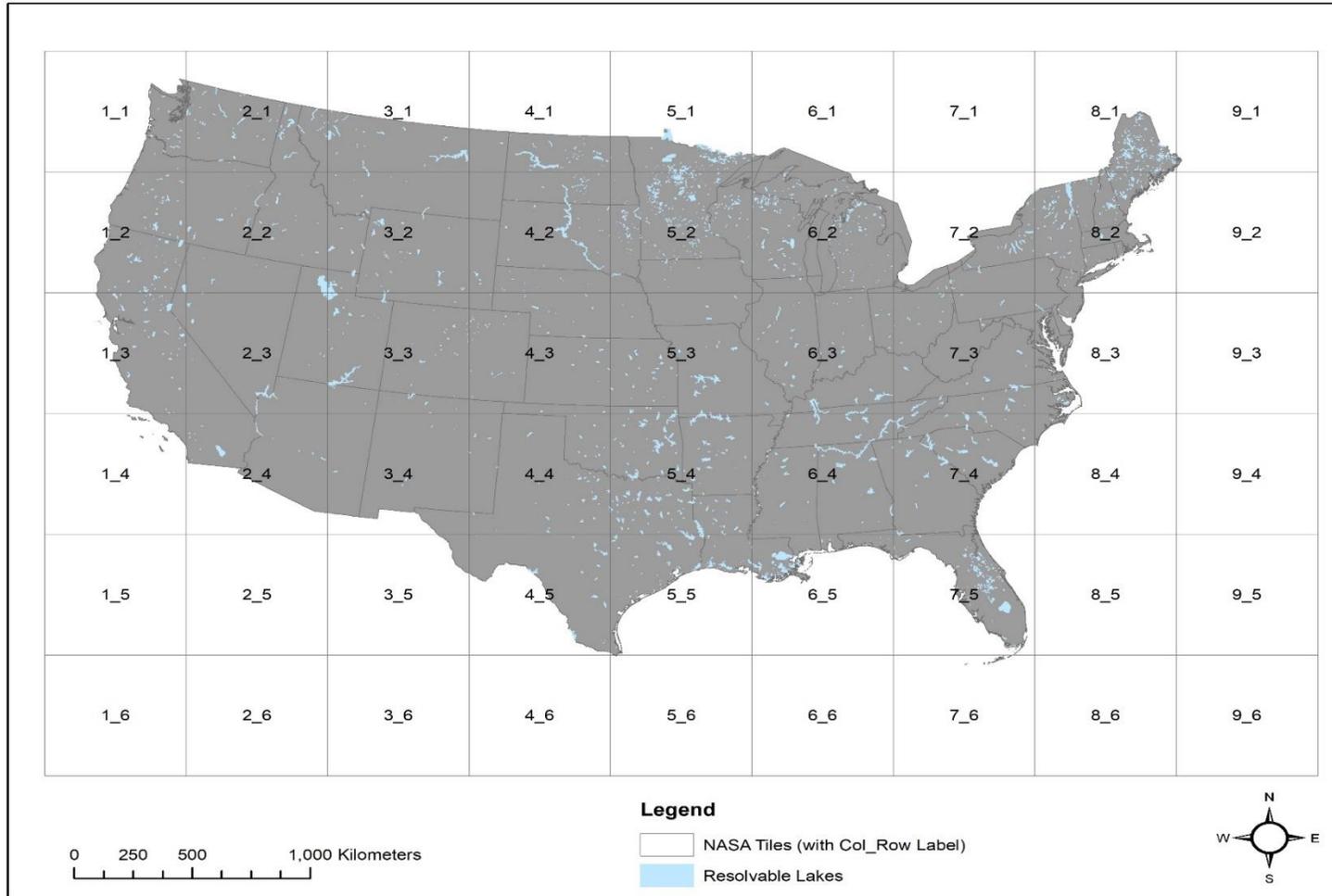
Identify landscape linkages causes of chlorophyll a and cyanobacteria.

Health

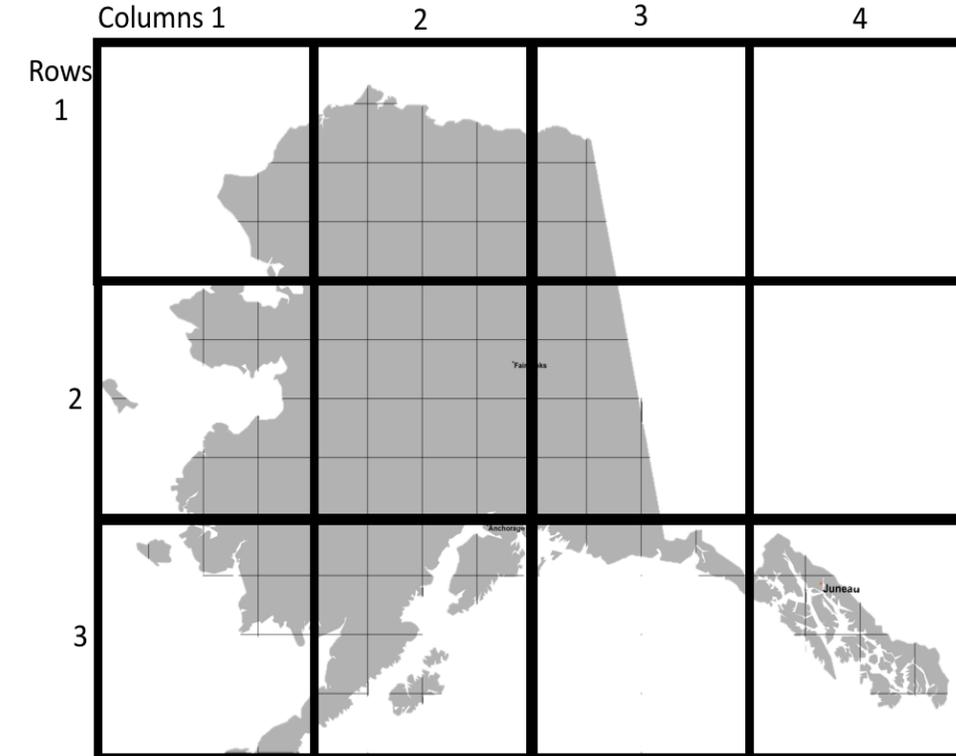
Exposure and human health effects in drinking and recreational waters.



Contiguous US (CONUS) tiles



Alaska tiles

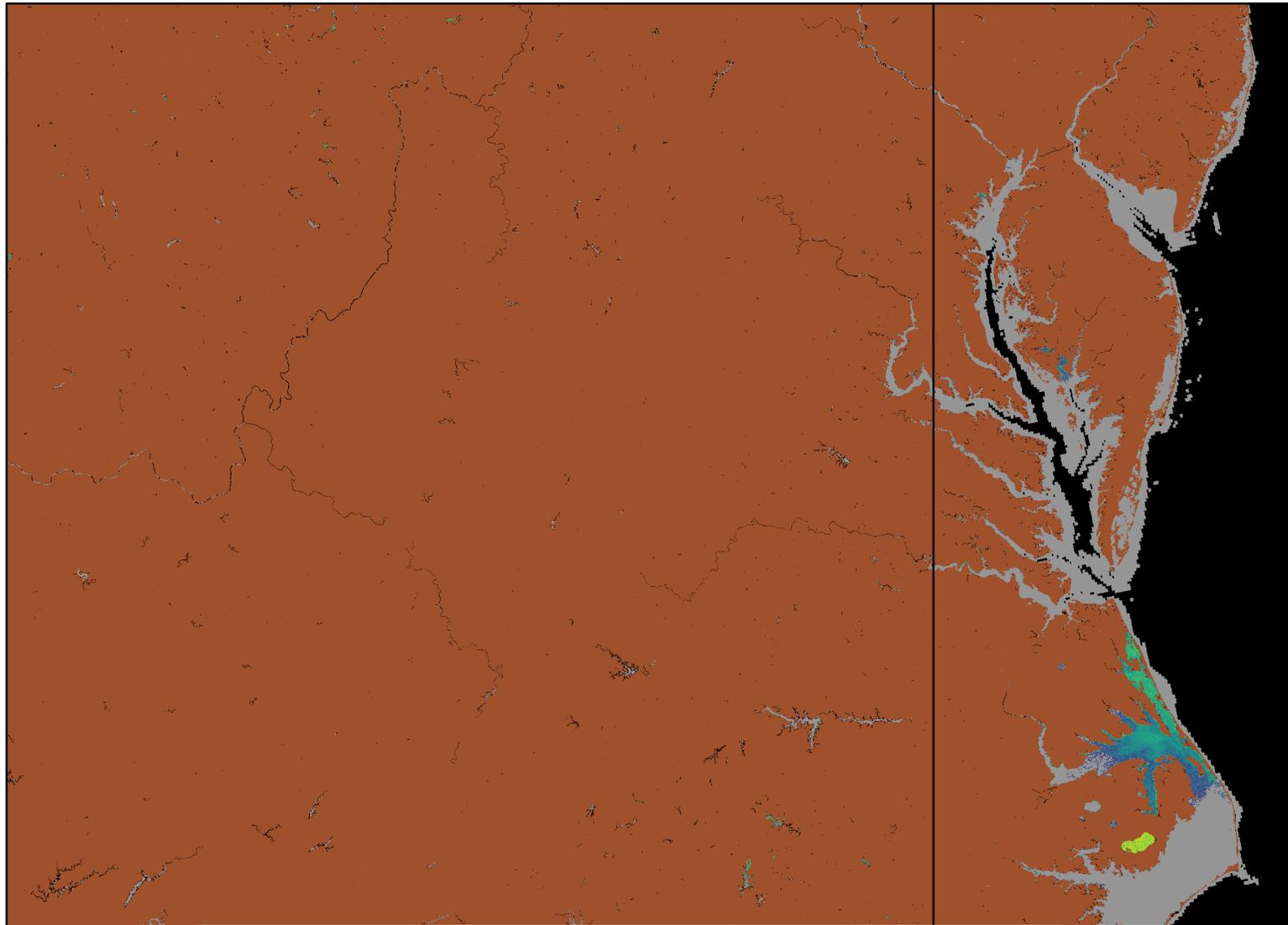


MERIS (2002-2012) and OLCI (2016-) Full resolution (300 m)

Website with entire time-series will be available at NASA soon!



Cyanobacteria
Assessment Network



Cyanobacterial Density



VA 2 Tiles

Mapped @300m

Nov 4, 2020, 1 day image

Cyanobacteria Index (CI)

OLCI Image

Spatial 300m

Temporal 2-3 days

MERIS (2002-2012)

OLCI (2016-)

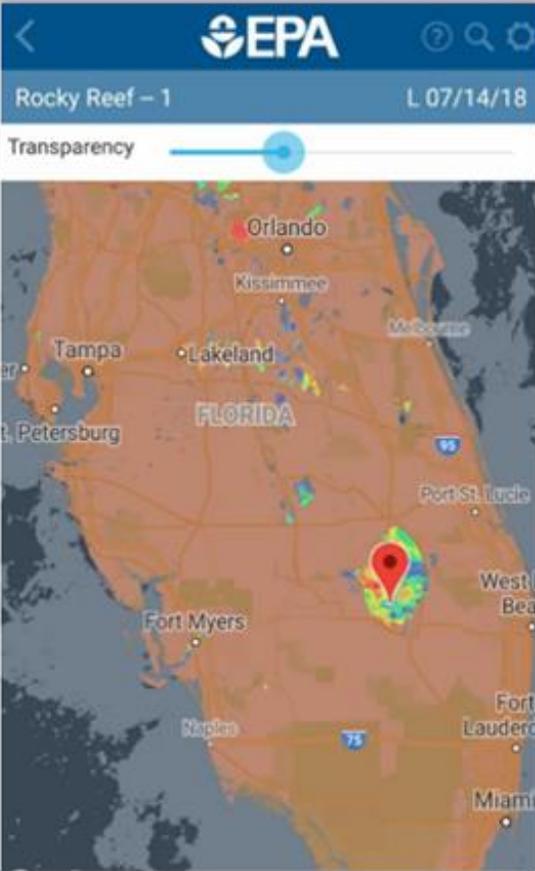
OLCI Images

from ESA satellite Sentinel 3a (soon 3b)



Cyanobacteria
Assessment Network

CyAN App



App makes it possible to

- easily share data and information with large numbers of people
- focus on individual lakes, current conditions and historic
- compare lakes of interest

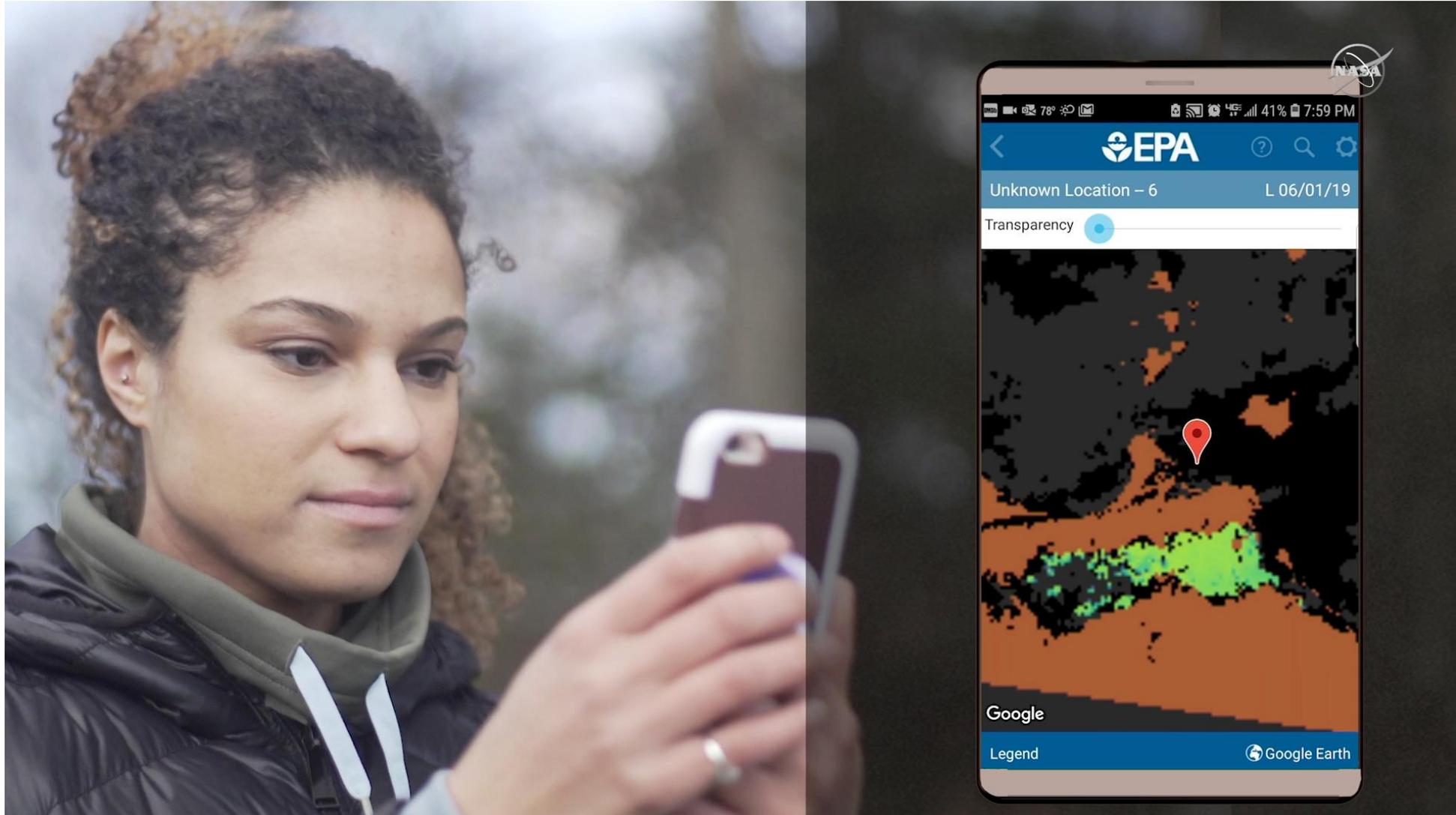
<https://www.epa.gov/water-research/cyanobacteria-assessment-network-mobile-application-cyan-app>



(12) United States Patent Schaeffer et al.	(10) Patent No.: US 10,290,089 B2
	(45) Date of Patent: May 14, 2019
(54) CYANOBACTERIA ASSESSMENT NETWORK	<i>H04W 4/02</i> (2018.01) <i>G06F 16/9537</i> (2019.01) <i>H04L 29/08</i> (2006.01)

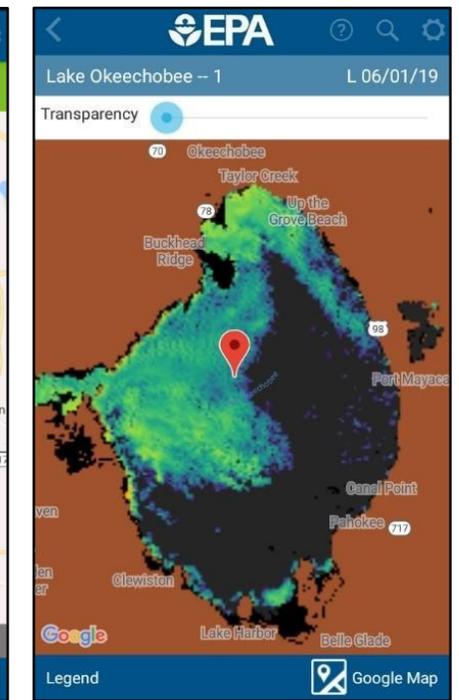
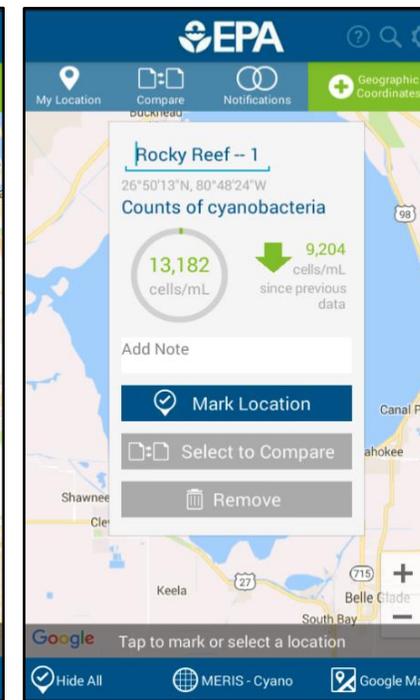
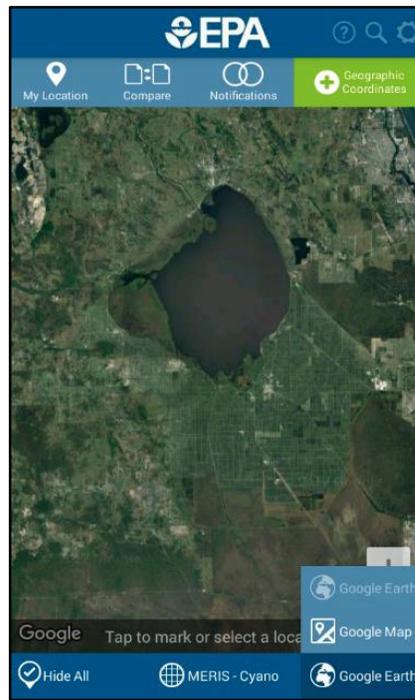
CYAN App

App uses weekly images

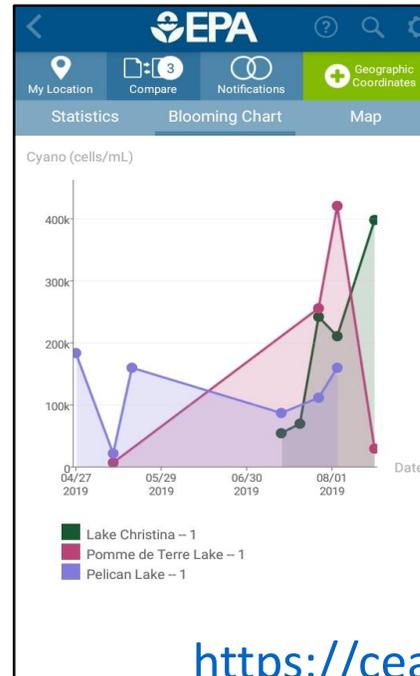


CYAN App

Look at lake of interest



Compare lakes and locations



Android only
Web interface available
to management agencies

For Access email Michelle.Tomlinson@noaa.gov
or Galvin.Mike@epa.gov

<https://ceamstg.ceeopdev.net/login/?next=/cyanweb/>

CyAN App Love



Aaron Borisenko, State of Oregon Department of Environmental Quality:

“... using CyAN app as an early warning system.”

Benjamin Holcomb, Utah Department of Water Quality:

“... allows UDWQ to better target field sampling and more efficiently use our limited resources to protect public health...”

Angela Shambaugh, Vermont Department of Environmental Conservation:

“... visualize that patchiness and provides additional context...”

Bart Johnsen-Harris, Environment America:

“...CyAN has proved to be a uniquely helpful tool.”

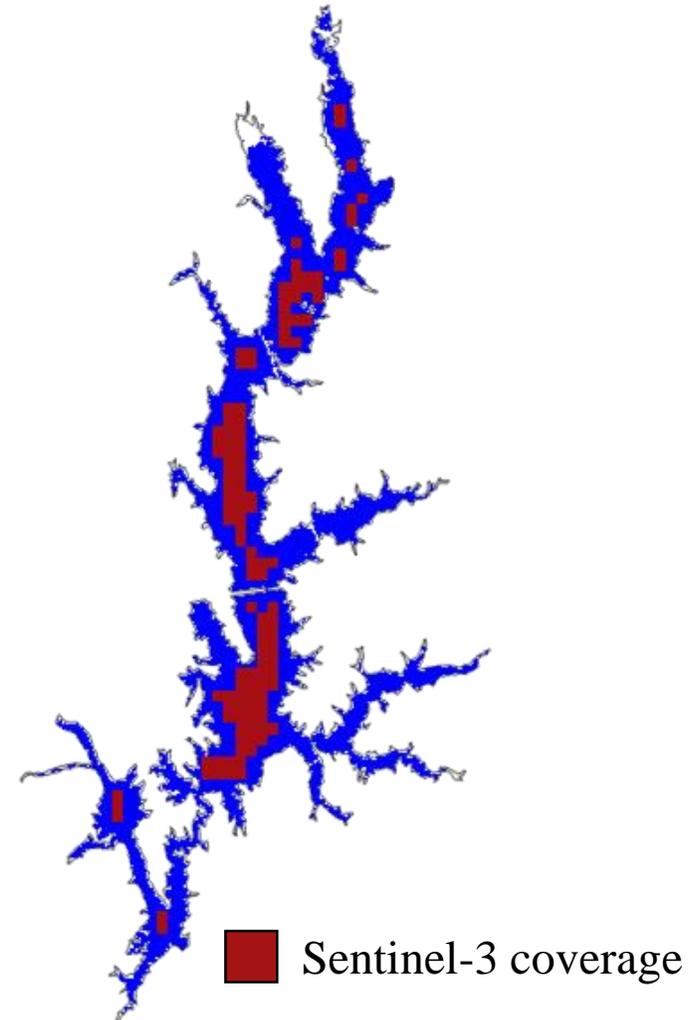
Lenard Long, Lake Cascade Citizen Scientist Monitoring Group:

“...enhance the community's ability to rapidly respond to and manage the growing threat posed by toxic algae...the CyAN app helps us do that....has been extremely useful....”



Challenges and limitations

- Toxins
- Depth
- Clouds, snow/ice
- Lake level change
- Small lakes, shorelines, rivers

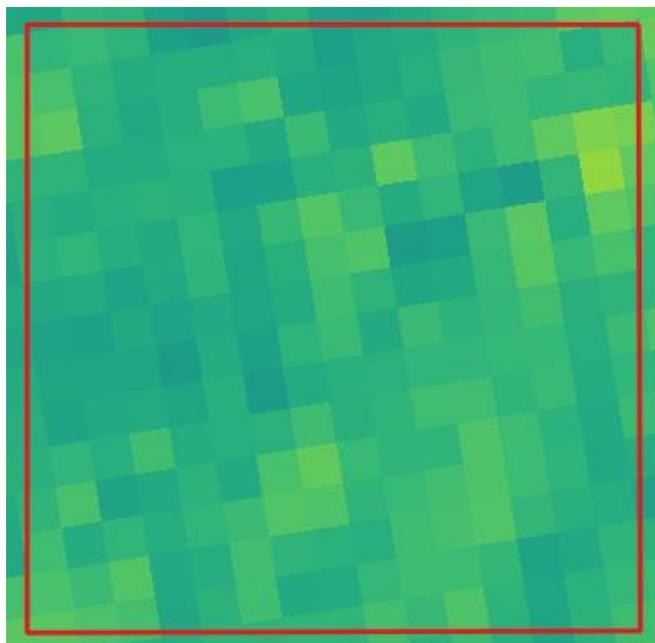




Sentinel-2



Sentinel-3 pixel

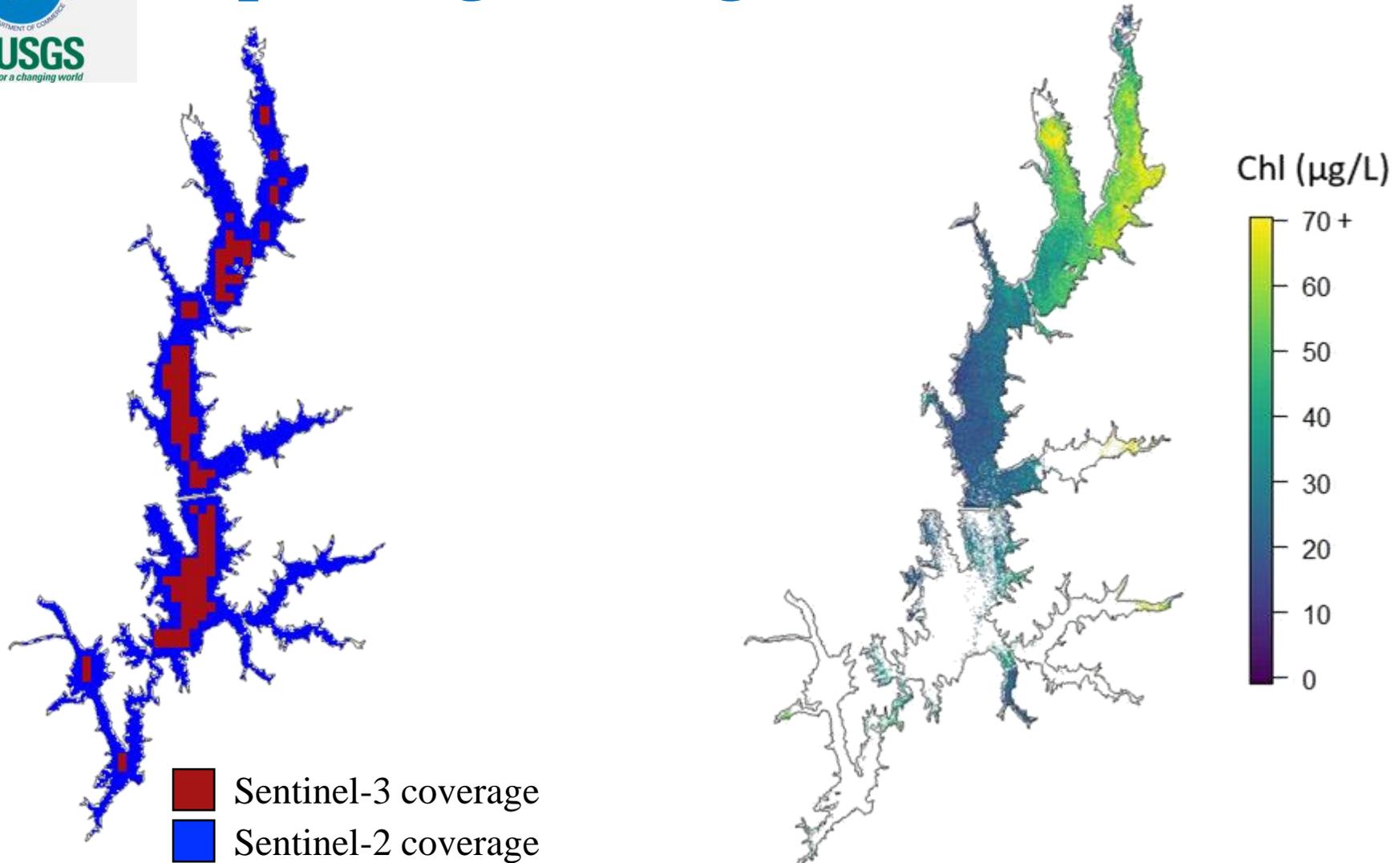


300 m

Sentinel-2 pixel
| 20 m



Expanding coverage



HABscope Integrated Approach

- Satellite imagery drives where and when to start sampling
- Sampling
- User groups provide continual feedback on cell phone microscope, presentation of data, accuracy, etc.
- Build on existing networks, Docent programs, Master Naturalist (e.g. Texas Red Tide Rangers), community groups, etc.
- Move from “lab” to the beach for analysis



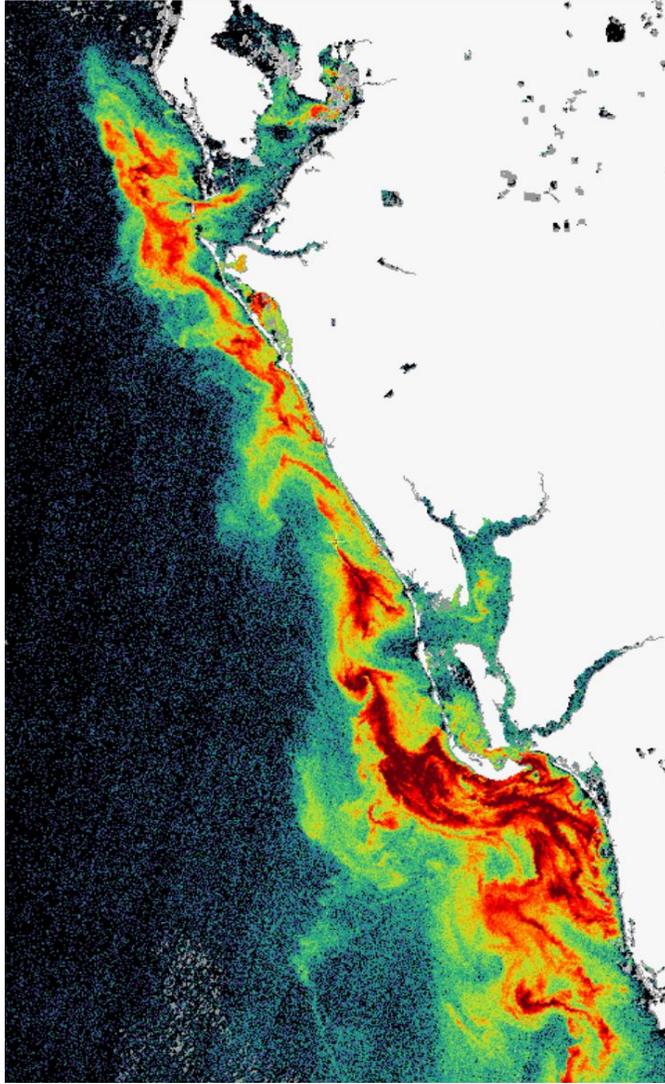
Red Tide Ranger analyzing samples in lab



GULF OF MEXICO
COASTAL OCEAN
OBSERVING SYSTEM



August 22, 2018



Fluorescence provides area of likely bloom (Sentinel-3)

A screenshot of the HABscope web interface in a Google Chrome browser. The browser address bar shows the URL 'https://habsc...'. Below the browser, there are two input fields containing the coordinates '-82.45815' and '28.91692'. Below these fields are three buttons: 'Capture Video', 'Upload Video', and 'Log out'.



Slides courtesy of Chris Holland, NCCOS/NOAA

Summary

- Satellites are a good way to monitor
- End-user engagement early
 - trainings (product and software)
 - product feedback
 - success stories
- Easy Data Access and Interface
- Outreach

Thank you!

Contact: Michelle.Tomlinson@noaa.gov

Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government. The views expressed are those of the authors and do not necessarily reflect the views or policies of the U.S. Government."



Extra Slides For Application developed
for California

California Cyanobacteria and HAB Network Website:

mywaterquality.ca.gov/habs/data_viewer

The screenshot shows the homepage of the My Water Quality website. At the top, there is a search bar and a navigation menu with links for Home, Portals, About Us, Workgroups, and HABs Links. The main heading reads "Are harmful algal blooms affecting our waters?" followed by the subtitle "CYANOBACTERIA AND HARMFUL ALGAL BLOOM NETWORK OF THE CALIFORNIA WATER QUALITY MONITORING COUNCIL". Below this, the "HAB Data Viewer" section is highlighted, with sub-links for "Satellite CyanoHAB Map", "Pre-Labor Day Assessment 2019", and "Archived Data". The "Satellite CyanoHAB Map" section contains a paragraph explaining the map's purpose as a screening tool, a list of important information about the satellite map, a contact email for Keith Bouma-Gregson, and a link to view the satellite data. A disclaimer is also present.

HAB Data Viewer

[Satellite CyanoHAB Map](#) | [Pre-Labor Day Assessment 2019](#) | [Archived Data](#)

Satellite CyanoHAB Map

This map displays estimated amounts of cyanobacteria in large water bodies calculated from satellite imagery. The map includes approximately 250 waterbodies in California large enough to be detected by the satellite. It is designed as a screening level analysis tool. For example, if the satellite shows a potential bloom, this can prompt field verification and sampling to confirm the status of a potential cyanobacteria harmful algal bloom. Decisions for health advisory postings will be made based on results from water quality samples. No regulatory decisions, or signage postings, should occur based solely on information from the map. More information about freshwater harmful algal blooms can be found at: mywaterquality.ca.gov/habs

Important information about the satellite map:

- The map shows estimates of cyanobacterial abundance near the surface of a waterbody.
- The map does not show any information about toxin concentrations and public health advisories.
- The map shows data collected over a 10-day window and does not display real-time conditions at a waterbody.
- All data on the map are currently considered provisional.

Contact Keith Bouma-Gregson with questions about the map: keith.bouma-gregson@waterboards.ca.gov

[View the satellite data.](#)

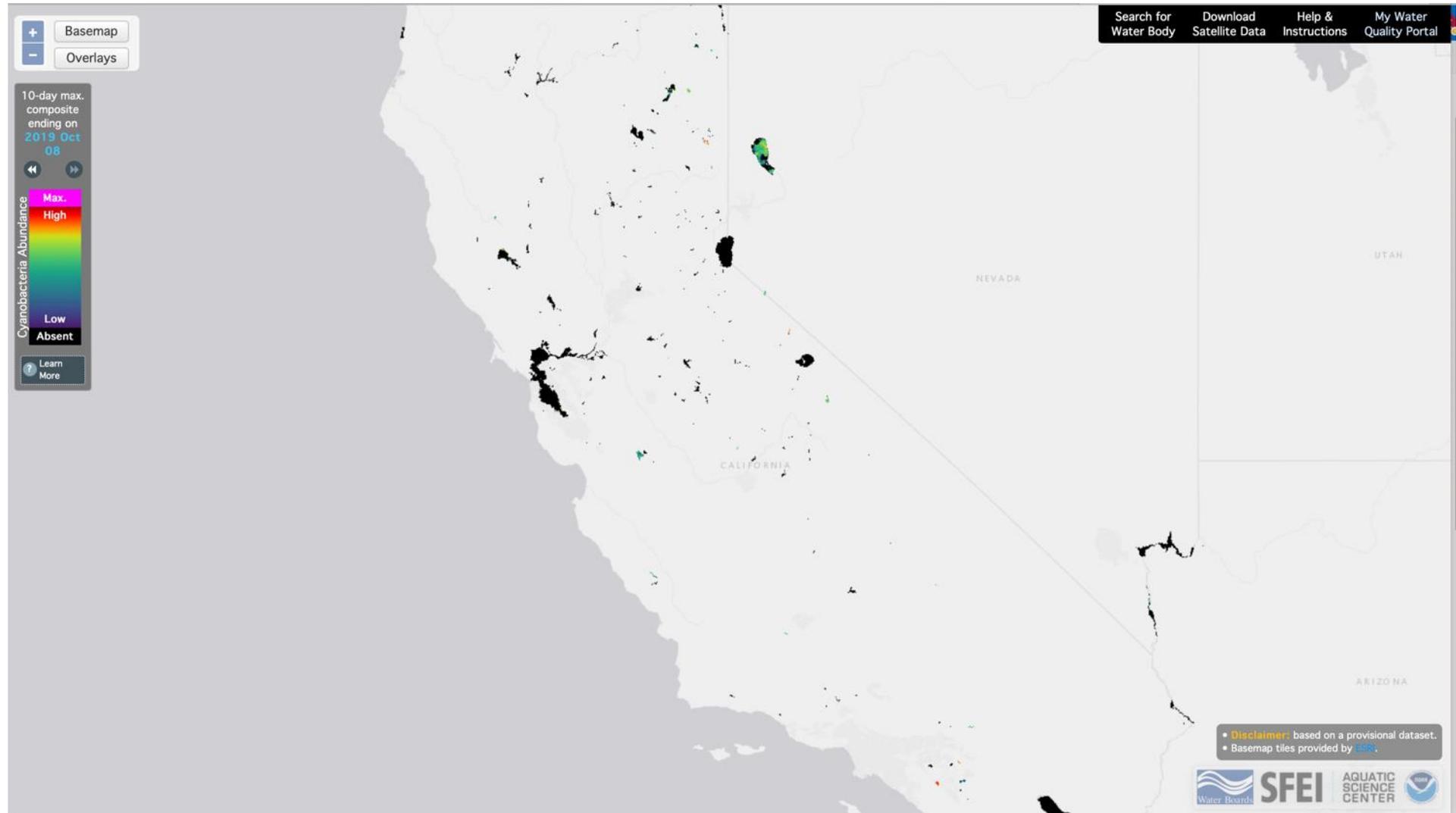
Disclaimer:
In no event shall the creators, custodians, or distributors of this information be liable for any damages arising out of its use. These data are not legal documents or of survey quality and are not intended to be used as such. Although effort has been made to produce error-free and complete data, all geographic information has limitations due to the scale, resolution, date and interpretation of the original source materials. Data may be subject to change without prior notification. We request that the use of these data in any map, publication, or report should cite the data source(s) used and give proper attribution and credit to the originators of the data.

Slides Courtesy of Keith Bouma-Gregson
CA Water Board in collaboration with
San Francisco Estuary Institute

Contacts:

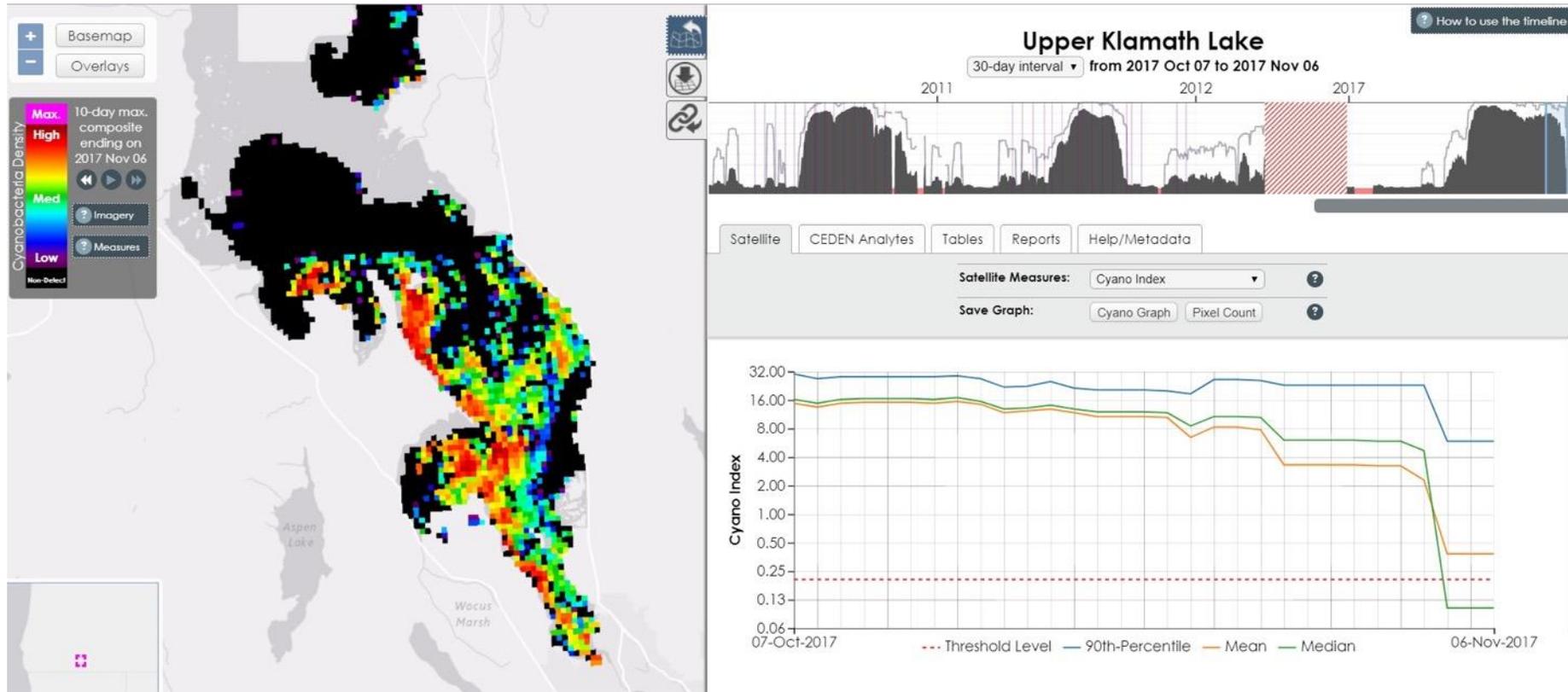
Keith.Bouma-Gregson@waterboards.ca.gov
randyt@sfei.org

Website: mywaterquality.ca.gov/habs/data_viewer



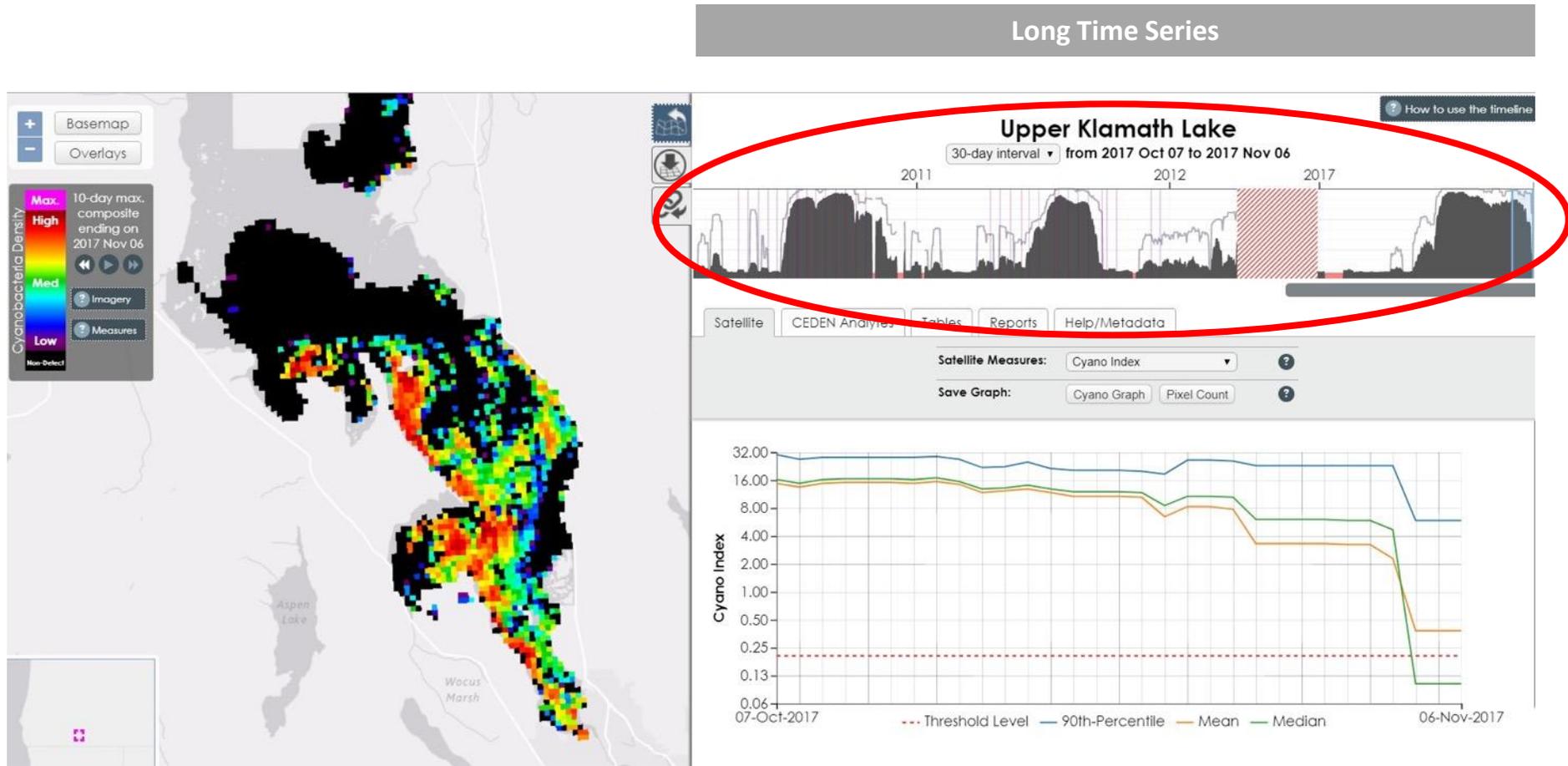
Website visualization interface

mywaterquality.ca.gov/habs/data_viewer



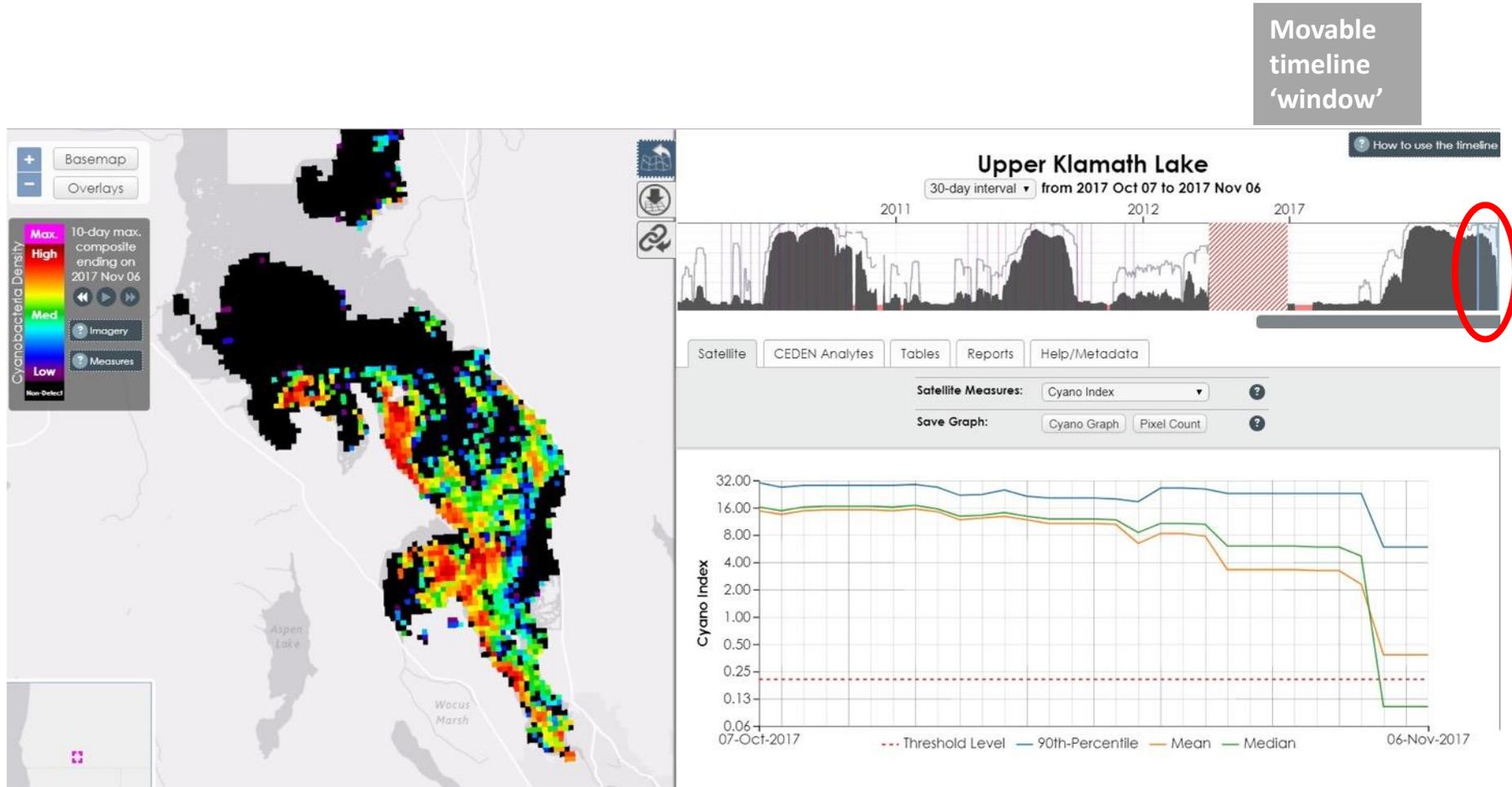
Website visualization interface

mywaterquality.ca.gov/habs/data_viewer



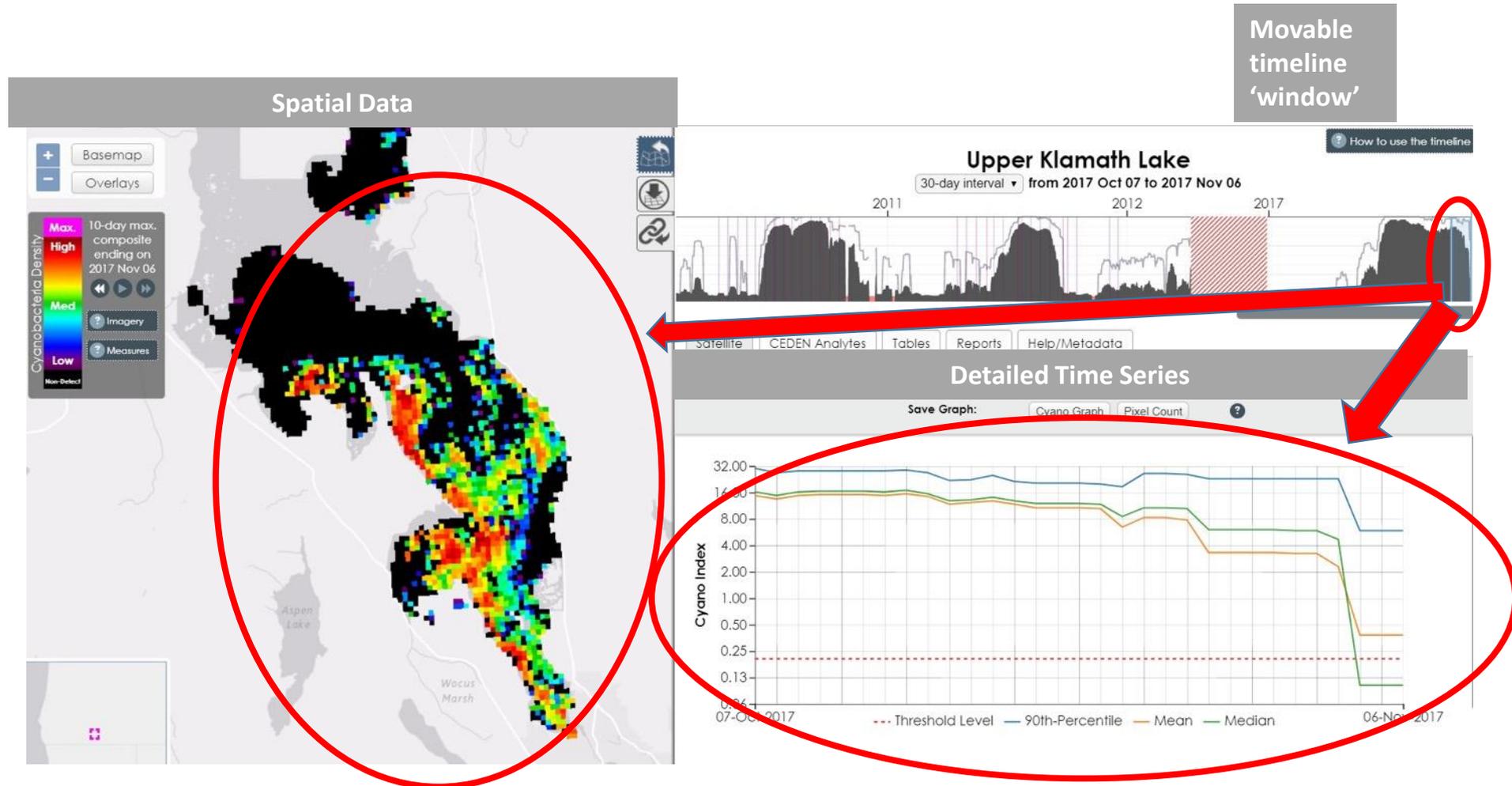
Website visualization interface

mywaterquality.ca.gov/habs/data_viewer



Website visualization interface

mywaterquality.ca.gov/habs/data_viewer



Management uses

- Data considered provisional, no postings
 - Screening tool for waterbody field assessments
 - Emails sent out when above the Clcyano threshold of 3.2
 - Early warning tool
 - Shoreline pixel masking limits its application
 - Chose not to display any cells/mL equivalents due to uncertainty about the correlations with cell density
 - Plans to expand and improve fhab.sfei.org with new Water Boards and SFEI contract in 2021
- Future potential use for:
- Historical trends
 - Landscape risk assessment
 - Secondary lines of evidence for 303d impairment listings

